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DRYLAND PASTURE AND CROP CONDITIONS AS SEEN BY HCMM

Progress Report for Period
July — October 1980

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Greenbelt, Maryland 20771

Contract NAS5-24383

TEXAS A&M UNIVERSITY
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DRYLAND PASTURE AND CROP CONDITIONS AS SEEN BY HCMM

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TABLE OF CONTENTS

1.0 BACKGROUND AND SUMMARY

1.1 Background

This 34-month project is an extension of several other projects which involve estimates of wheat yield (Harlan et al., 1978), green biomass (Deering et al., 1977) and watershed run-off coefficient (Blanchard, 1978) using visible, near infrared and passive microwave data. In each estimate, soil moisture content is a major determining factor. The hypothesis of this study is that high resolution thermal infrared data, such as those received from HCMM, will enhance estimates of soil moisture content. Therefore, the three objectives of this project, as given in the statement of contract NAS5-24383, are:

1) to assess the capability for determining wheat and pasture canopy temperatures in a dryland farming region from HCMM data.

2) to assess the capability for determining soil moisture from HCMM data in dryland crops (winter wheat) from adjacent range lands.

3) to determine the relationship of HCMM-derived soil moisture and canopy temperature values with the condition of winter wheat and dryland farming areas during the principal growth stages.

To accomplish these objectives, measurements will be obtained at three levels: ground truth, aircraft, and satellite. The site selected for these measurements is on the Washita River watershed, near Chickasha, Oklahoma. The area has a dense USDA/SEA-AR network of rain gages, and rangeland and dryland winter wheat are often adjacent to each other. Ground truth data include canopy and lake surface temperatures, neutron probe and gravimetric soil moisture samples, and daily precipitation data. The aircraft collected day/night thermal scanner data and aerial photos of commercial wheat and pasture fields; HCMM has collected day/night thermal imagery over the same site, in addition to a site near Colby, Kansas. Data collected from each level will be correlated in two ways:

1) thermal (HCMM and aircraft) parameters of soil moisture and crop canopy temperatures will be derived,

2) a technique will be developed to calculate the antecedent precipitation indices from the thermal parameters of soil moisture and canopy temperatures, and

1.2 Summary

Accomplishments during the eleventh period of the contract (July - October 1980) include

1. Screening IR data to include areas having greater than 60% pasture

2. Recalculating surface temperatures using the atmospheric correction factor calculated by the modified RADTRA model, and

3. Analyzing the July 29, 1978 IR data.

Screening the IR data improved the relationship for July 24/July 13 and October 7/August 31 temperature/API relationship. However the coefficient of determination was not improved in the July 29/July 13 relationship.

In all cases the correction factor was reduced. The model estimate and lake surface temperatures may be used to calibrate IR data if no meteorological data is available.

The July 29, 1978 IR scene was analyzed and temperature differences between this date and July 13 were compared to concurrent API conditions. No significant relationship is apparent, and the coefficient of determination ($R^2 = 0.25$) was approximately the same as the coefficient for the July 30/July 13 relationship.

2.0 ACCOMPLISHMENTS AND PROBLEMS

2.1 Accomplishments

During the eleventh period of the contract, work was primarily emphasized on 1) screening IR data for pasture areas, 2) recalculating the atmospheric correction factor using the modified RADTRA model, and 3) analyzing the relationship of the July 29/July 13 temperature difference with API.

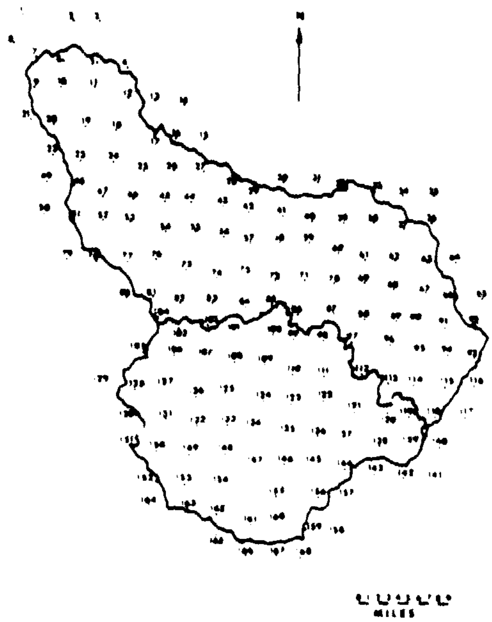
To diminish the thermal effect of land use variability in the sample sites, IR data was screened for pasture areas. Any site having less than 60% pasture in the one square kilometer area around each raingage was removed from the data. The list of 58 raingage sites eliminated are listed in Table 1. Figure 1 shows the raingage sites over the watershed. Coefficients of determination were then recalculated for the July 24/July 23 thermal vs API, July 30/July 13 thermal vs API, and October 7/August 31 thermal vs API relationships. The coefficients increased for all dates. The July 24 relationship improved from 0.53 to 0.48, the July 30 relationship from 0.08 to 0.25, and October 7 from .35 to .43. Consequently, a higher proportion of the API variance can be explained by the variance in day/day temperature differences once the effect of land use variability has been removed.

In addition we recalculated the atmospheric correction using the modified RADTRA model sent to us during the last period. The model was applied with meteorological inputs from October 17 and July 24. The October 17 adjustment was 0°C, while the July 24 correction was 1.12°C. The lake surface temperature correction was 1°C ± 1°C. Since the two estimates are essentially the same, lake surface temperatures

Table 1.

List of Rain Gage Sites
Having Less Than 60% Pasture

Rain Gage	Rain Gage	Rain Gage
1	62	102
2	68	103
3	72	104
7	73	105
8	79	112
9	80	113
10	81	119
20	82	120
21	83	121
22	84	130
23	85	131
46	86	136
48	87	140
49	88	149
50	97	150
51	98	151
52	99	152
53	100	153
57	101	163
		164



WASHITA WATERSHED
RAINGAGE SITES

Figure 1

--being the simpler technique--can adequately calibrate satellite thermal infrared data.

During this period, the July 29, 1978 scene was analyzed; Figure 2 is a greymap of the thermal IR data collected over the watershed. Note the faint cool band having the same shape as the rainfall pattern on July 21. Clouds did not affect surface temperatures which ranged from 32° to 37°C. The difference between the satellite lake temperature and actual lake temperature was +6°C. The air temperature was the same as for July 13. Consequently, the adjustment factor was +6°C, and adjusted temperatures were from 38°C to 43°C. The same technique as described in previous reports was followed in determining temperature differences between July 29 and July 13. In addition, the data was screened for pasture. The relationship between temperature difference and API is given in Figure 3. The coefficient of determination is quite low ($R^2 = .25$), yet similar to the coefficient determined on July 30. Such a low coefficient indicates variability in land use is still affecting estimates of API below 1 cm. Above 1 cm, a linear trend is still slightly evident. Plotting the regression line calculated for the July 24/July 13 relationship as a dotted line on Figure 3, the relationship holds fairly well for the few points above 1 cm. If this relationship holds on both dates, then the IR normalization technique using lake temperature and air temperature may be adequate. More satellite infrared and actual temperature data are needed to confirm this technique. Comparing the coefficients of determination for the July 24/July 13, and July 29/July 13 relationships, a significant drop from 0.58 to 0.25 is noted. Such a drop

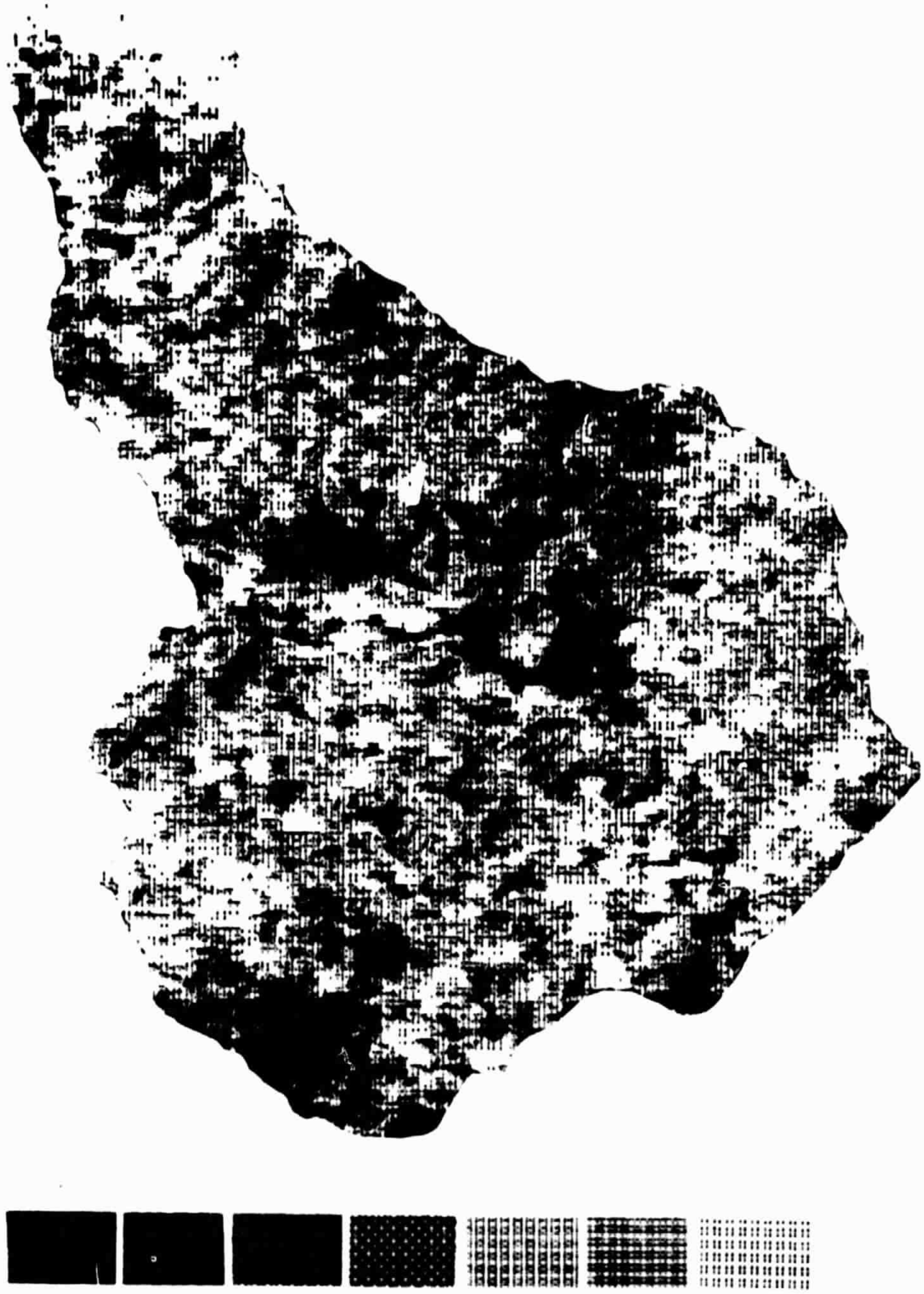


Figure 2. Thermal infrared greymap of the Washita watershed on July 29,1978.

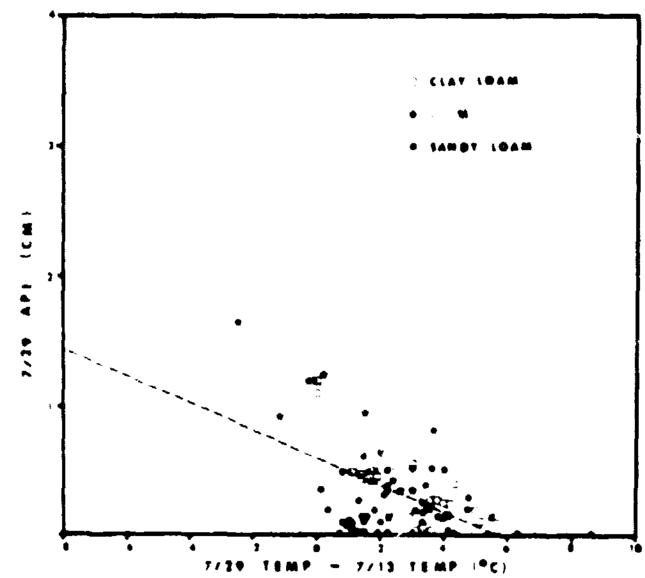


Figure 3. Day/day temperature differences between July 29 and July 13 versus July 29 API differences (dashed line -- 7/29-7/13 regression line; dotted line -- 7/24-7/13 regression line).

indicates that reliable soil moisture (API) estimates greater than 1 cm are possible from day/day thermal IR data for a period up to approximately 7 days. This was the case under a hot, dry summer. Different climatic conditions may lengthen the period. Consequently, more analysis is needed under different conditions to quantify this period, which can be very important in determining overpass intervals for future thermal infrared satellites.

2.2 Problems

As of October 25, two 1978 day/night registered CCT's--October 6/7 and 11/12--have not been received. The images for both sets have been received and much useful data is on both sets. Comparisons between day/day and day/night thermal relationships are being delayed due to the lack of data. If the data do not arrive during the next quarter, we will be unable to adequately examine the relationship of day/night temperature differences versus API.

2.3 Future Accomplishments

If the two data sets--October 6/7 and 11/12--arrive during the next quarter, day/night temperature differences will be related to API. In addition the day/night relationships will be compared to day/day relationships for the same period. The comparison should display the need for night IR data.

In addition, the results of the July 24/July 13 and July 29/July 13 relationships will be submitted to a journal yet to be determined.

3.0 SIGNIFICANT RESULTS

Day/day surface temperature differences from HCMM are related to antecedent precipitation index (API) up to approximately seven days after a storm on July 21, 1978. After that period, the coefficient of determination decreased to 0.25 indicating other factors, such as land-use variability within each measurement site (5 square kilometers), are influencing temperature variation. Other data sets need to be analyzed to confirm the temperature difference/API sensitivity period.

During the eleventh period (July - October 1980) a large portion was spent on salary and wages. During this period, $8,322 were spent, bringing the total to $98,364 or 85% of the total budget. During the next period, computer processing of CCT data--if the data arrives--and drafting supplies will comprise a large portion of the expenditures. Table 2 gives a breakdown of the funds expended.

TABLE 2

Funds Expended

	First Six Quarters	Seventh Quarter	Eighth Quarter	Ninth Quarter	Tenth Quarter	Eleventh Quarter
Supplies	692	0	55	1,536	31	72
Travel	3,224	268	1,745	1,161	458	1,416
Other Direct Costs	11,709	175	217	2,029	422	918
TOTAL DIRECT COSTS	15,625	443	2,017	4,726	911	2,406
Salaries and Wages	24,996	5,967	3,447	9,517	1,632	4,508
TOTAL INDIRECT COSTS	11,294	2,806	1,554	4,380	727	1,408
TOTAL COSTS	51,815	9,216	7,018	18,723	3,270	8,322

5.0 AIRCRAFT AND SATELLITE DATA USAGE

The July 29, 1980 IR data were handled and processed in the same manner as described in previous progress reports:

1) thermal infrared greymaps were produced at 1:250,000 to aid in locating the watershed raingage sites,
2) temperature averages were determined for one square kilometer areas around each raingage,
3) surface temperatures were calibrated using actual lake surface temperatures,
4) surface temperatures were normalized to July 13 temperatures by using air temperature,
5) sample areas having less than 60% pasture were eliminated from the data set, and
6) temperature differences were calculated at each remaining raingage site.

Comparing results for the July 24/July 13 and July 29/July 13 relationships, the normalization technique appears to work well.

The REMOTE SENSING CENTER was established by authority of the Board of Directors of the Texas A&M University System on February 27, 1968. The CENTER is a consortium of four colleges of the University; Agriculture, Engineering, Geosciences, and Science. This unique organization concentrates on the development and utilization of remote sensing techniques and technology for a broad range of applications to the betterment of mankind.